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LARVAL DEVELOPMENT UNDER LABORATORY CONDITIONS OF THE TROPICAL SPIDER CRAB *MITHRAX* (*MITHRACULUS*) *CORYPHE* (HERBST, 1801) (BRACHYURA: MAJIDAE)

Liberta E. Scotto and Robert H. Gore

Abstract.—The larval development of *Mithrax* (*Mithraculus*) *coryphe,* a tropical American shallow water marine spider crab is described and illustrated from stages cultured in the laboratory, and compared with larvae of *Mithrax* (*Mithraculus*) *forceps* (A. Milne Edwards, 1875). Development consists of two zoeal and a megalopal stage; a prezoeal stage is hypothesized but was not observed. Temperature affects duration of development with both zoeal stages lasting 2 days each at 30°C and 3 days each at 25°C. No first crab stages were attained, but data obtained from the megalopal stages at both temperatures allowed a planktonic duration of about 10 days to be extrapolated. Larvae of *M. coryphe* are almost identical in most morphological features to those of *M. forceps,* so separation of the zoeae in the two species will be difficult; megalopal stages are more easily distinguished. Similarity in larval and postlarval stages corresponds with the general morphological similarity exhibited by adults of the two species.

Mithrax (*Mithraculus*) *coryphe* is a tropical American marine spider crab distributed from the Indian River region on the central eastern Florida coast, southward throughout the eastern and southwestern Caribbean, to São Paulo, Brazil (Powers, 1977; Velez F., 1977). It is associated with rocky or coralline habitats, or seagrasses, from the intertidal zone to 55 m. The larval development of members of this genus has been little studied (see Wilson *et al.,* 1979, for summary), in spite of the easy accessibility of their habitats and the relative abundance of specimens. In a previous paper (Wilson *et al., loc. cit.*) we described the complete larval development for *Mithrax* (*Mithraculus*) *forceps,* and compared morphological features in the larvae of that species to those exhibited by larvae in the subgenus *Mithrax* (*Mithrax*). In this paper we continue our investigations on this genus, by providing illustrations of the larval development of *M. coryphe,* and comparing it to larvae of *M. forceps.* This is but the third report on larvae within the genus *Mithrax,* and the second within the subgenus (*Mithraculus*).

Materials and Methods

Two ovigerous females were collected from Ninguange Lagoon, Santa Marta, Colombia, from a milleporine patch reef in 1 m of water, on 23 May

1979. The specimens were held in 8.5 cm covered glass laboratory dishes in nonflowing seawater (35‰) until hatching occurred in one female on 3 June. A total of 96 larvae, divided evenly among 4, 24-compartmented plastic trays, was cultured in controlled temperature units (CTU) at 25° and 30°C. A single tray (24 individuals) at 25°C was inadvertently starved on the day of hatching; the remaining tray at 25°C, and both trays at 30°C received *Artemia* nauplii daily; all trays received fresh seawater (35‰) daily. Light in the CTU's was on a diel cycle, 12 hours on, 12 hours off.

Illustrations and measurements of larvae were made as in the previous study (Wilson *et al.*, 1979). The descriptions and illustrations below are based on zoeae and megalopae obtained in the fed series at 25° and 30°C.

Laboratory Culture Experiment

The larval development of *Mithrax coryphe* consists of two zoeal stages, and a megalopal stage. Whether a prezoeal stage occurred is unknown; none was observed the morning of the hatch. However, other members of the genus begin their larval development with such a stage, albeit of very short duration. It is thus possible that the stage took place but was passed before the trays were examined. Duration of development in the zoeal and megalopal stage is presented in Table 1, and the percentage of larval survival is illustrated in Figure 1; both show that the duration of larval development is temperature-dependent. The minimum time spent in each zoeal stage was 2 days at 30°C and 3 days at 25°C. Regrettably, megalopal stage development was not completed at any temperature. Consequently, no firm conclusion can be made as to postlarval duration or total larval development. However, if the duration of the megalopal stage is comparable to that in *M. forceps*, then this stage probably lasts from 6–8 days. Using this value, the length of planktonic existence in *M. coryphe* at 30°C may be about 10 days, or slightly longer at 25°C. This duration is different from that observed in *M. spinosissimus* (Provenzano and Brownell, 1977), and *M. forceps* (Wilson *et al.*, 1979); the former required about 5–6 days, and the latter about 14 days, to complete planktonic development.

The larval series at 25°C which was starved for one day showed the effects of food deprivation on the early zoeal stage. The first zoeae required 5 days (as compared to 3 days in the fed series at 25°C) to complete development. Survival was poor, only 3 zoeae attaining stage II, and all dying as such. By laboratory day 4 only 12 of the original 24 zoeae starved on day 1 remained alive in stage I, whereas 19 of 20 surviving zoeae in the 25°C fed series had already molted to second stage. Three of the day-1-starved zoeae did attain stage II, but were apparently too debilitated to complete this stage; the greatest mortality in this series occurred prior to the molt to stage II. Contrarily, nearly all their counterparts in the fed series reached megal-

Table 1.—Duration of the larval stages of *Mithrax* (*Mithraculus*) *coryphe* at various temperatures.

Temperature (°C)		Duration (days)				
		Minimum	Mean	Mode	Maximum	Total number molting to next stage
25°C (Fed)	Zoeae I	3	3	3	3	19
	II	3	3.3	3	4	7
	Megalopa	1	—	4	4	All died in stage
25°C (Starved 1 day)	Zoeae I	5	5	5	5	3
	II	1	—	—	3	All died in stage
30°C (Fed)	Zoeae I	2	2	2	3	42
	II	2	2	2	2	26
	Megalopa	1	—	3	4	All died in stage

opa, but it was throughout this stage that the greatest mortality occurred. These data, admittedly brief, suggest that the early zoeal stages of *Mithrax coryphe* probably have insufficient amounts of yolk, or none at all, subsequent to eclosion, so that survival through the first zoeal stage requires an outside food source which must be available immediately upon hatching.

Best survival was seen in the 30°C series, a somewhat surprising result because generally at this temperature the increased speed of development and the shorter intermolt duration in the larvae often appear concomitant with higher overall mortality than is seen at cooler temperatures where the development is prolonged (e.g. Wilson *et al.*, 1979). We believe that individual larval variation in development can be ruled out as a possible explanation for the observed variance in mortality in *M. coryphe* because all the zoeae in this study came from the same hatching produced by a single female. However, the fact that *M. coryphe* is more of a tropical-subtropical species (based on distributional records), rather than a eurythermic-tropical species (*sensu* Briggs, 1974) may provide some explanation. If the species and its larvae were better adapted to warmer seawater temperatures, then presumably the larvae would complete their development faster at the higher temperatures, thereby settling out from the plankton sooner.

Description of Developmental Stages

The zoeae and megalopae of *M. coryphe,* while not completely identical to those of *M. forceps,* are sufficiently similar in most morphological characters to cause some difficulty in distinguishing between the two forms. But because an extensive description of the zoeae and megalopae of *M. forceps* is available (Wilson *et al.*, 1979), the following descriptions of larvae of *M. coryphe* will be limited to features which differ from those noted in *M. forceps,* i.e., structures not described are identical to those of *M. forceps.*

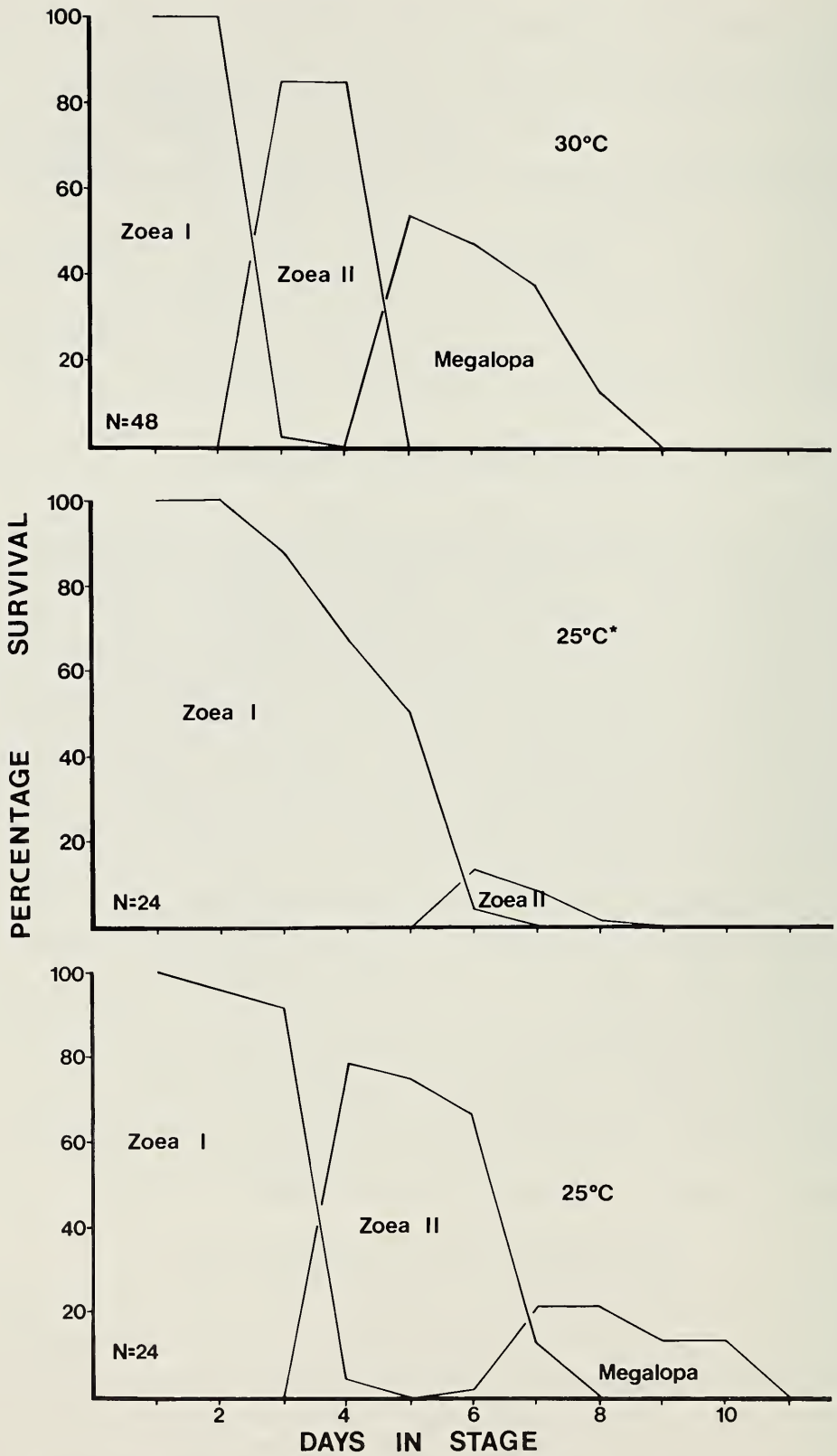

Fig. 1. Percentage survival and stage duration of *Mithrax coryphe* larvae reared under laboratory conditions. N = number of larvae cultured at each temperature; * = larvae starved on first day at 25°C.

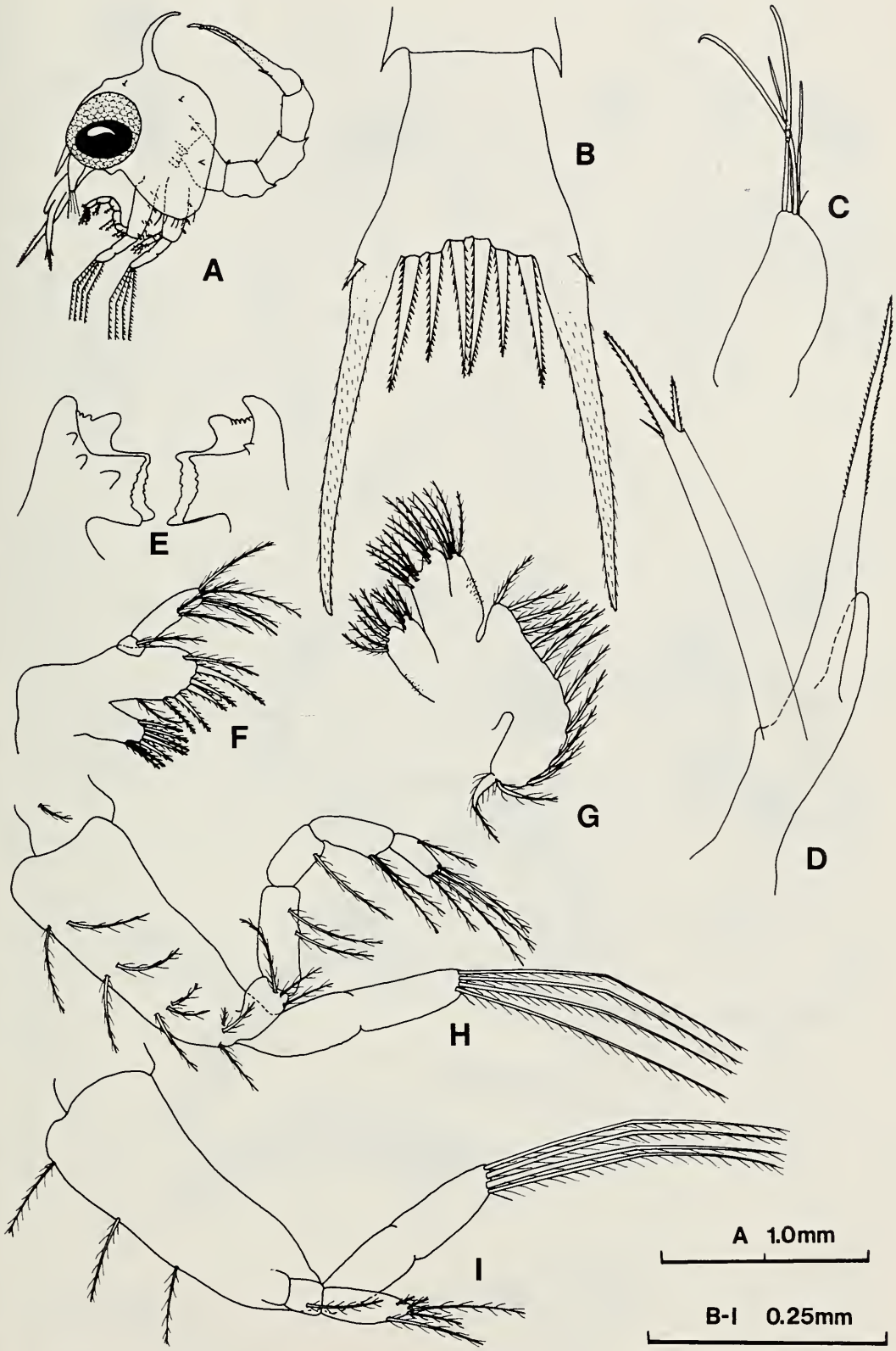

Fig. 2. *Mithrax coryphe*, first zoea: **A,** Lateral view; **B,** Telson; **C,** Antennule; **D,** Antenna; **E,** Mandibles; **F,** Maxillule; **G,** Maxilla; **H,** Maxilliped 1; **I,** Maxilliped 2.

Fig. 3. *Mithrax coryphe*, second zoea: **A**, Lateral view; **B**, Telson; **C**, Antennule; **D**, Antenna; **E**, Mandibles; **F**, Maxillule: **G**, Maxilla; **H**, Maxilliped 1; **I**, Maxilliped 2; **J**, Maxilliped 3.

Fig. 4. *Mithrax coryphe,* megalopal sensory and feeding appendages: **A,** Lateral view; **B,** Dorsal view; **C,** Antennule; **D,** Antenna; **E,** Mandibles; **F,** Maxillule; **G,** Maxilla; **H,** Maxilliped 1; **I,** Maxilliped 2; **J,** Maxilliped 3.

In order to facilitate identification and allow comparison between the larvae of the two species, all appendages in the zoeal and megalopal stages are completely illustrated. As in *M. forceps,* the measurements of larvae are based on the arithmetic averages of the specimens examined.

First Zoea.—(Carapace length: 0.67 mm; 10 specimens examined).

Carapace (Fig. 2A): As in *M. forceps,* but dorsal spine slightly more recurved; rostral spine inserted at different angle than in *M. forceps,* so that antennular rod in lateral view appears ventral to plane of rostral spine; in *M. forceps* antennular rod lies in same plane as rostral spine, obscuring latter. Setation number and position identical to *M. forceps*; thoracic appendages unsegmented, visible through carapace.

Telson (Fig. 2B): Slightly wider and longer than *M. forceps,* furcae slightly longer.

Mandible (Fig. 2E): Processes slightly less robust.

Color: Differs from *M. forceps* in that the basipodites of maxillipeds 1 and 2 are orange-rose with spidery black chromatophores ventrally; in *M. forceps* maxilliped 1 is transparent, with a single black chromatophore distally at junction of endopodite, whereas maxilliped 2 is colored similarly to that of *M. coryphe.* The posterior margin of the eyes, and the dorsal carapacial spine with orange-rose hue in *M. coryphe*; uncolored in *M. forceps.*

Second Zoea.—(Carapace length: 0.83 mm; 10 specimens examined).

Mandibles (Fig. 3E) remain stouter in *M. coryphe,* but otherwise identical.

Maxilla (Fig. 3G) nearly identical; scaphognathite in *M. coryphe* with 25 marginal setae (24 in *M. forceps*).

Maxilliped 3 (Fig. 3J) with epipodite bud, placed as illustrated; no bud observed, but possibly overlooked in *M. forceps.*

Color: Maxilliped 1 and 2 retain first stage coloration: *M. forceps* lacks chromatophores on maxilliped 1 in this stage; abdominal somites 1–4 lime-green with orange and black chromatophores ventrally; *M. forceps* abdominal color similar to stage I.

Megalopa.—(Carapace length × width: 1.15 × 1.05 mm; 10 specimens examined.

Carapace (Fig. 4A, B): Generally similar to *M. forceps,* although larger in size. Differs in placement of additional tubercle on gastric region, making total of 6 (instead of 5), placed 3,1,2 (instead of 3, 2); only 4 tubercles in arch on cardiac region (instead of 5 in *M. forceps*); general carapacial setation slightly more abundant in *M. coryphe,* placed as illustrated.

Abdomen (Fig. 4A, B; Fig. 5A–C): Setation slightly different but probably not significantly so.

Antennule (Fig. 4C): Identical in form and setation (but not in aesthetasc positioning and number) to *M. forceps*; in Wilson *et al.* the aesthetascs were stated to be placed in a V, progressing distally 2,2,2,1 but this should read,

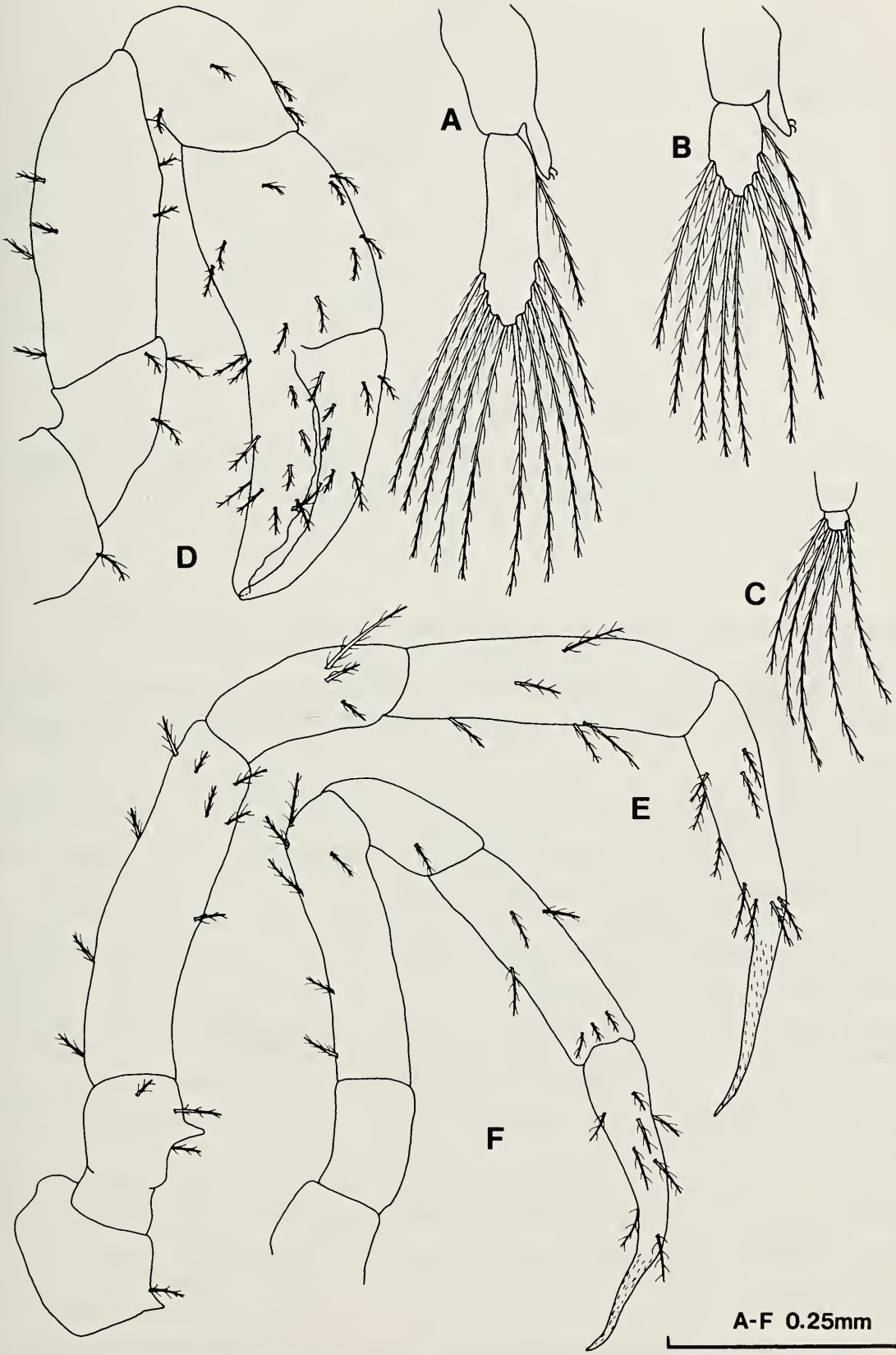

Fig. 5. *Mithrax coryphe*, megalopal locomotory appendages: **A–C**, Pleopods 1,4,5; **D–F**, Pereiopods 1,2,5.

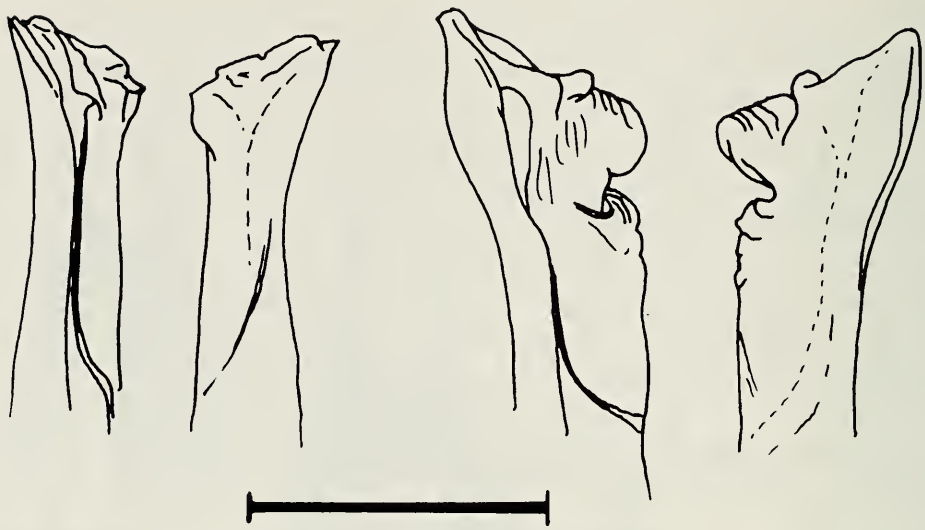

Fig. 6. Comparison of male gonopods in *Mithrax coryphe* (**left**) and *Mithrax forceps* (**right**). Sternal views on left, abdominal views on right of each figure.

progressing distally 1,2,2,2, instead; in *M. coryphe* 9 aesthetascs are positioned similarly, progressing distally 1,2,2,2,2.

Maxilla (Fig. 4G): Essentially similar; however, scaphognathite in *M. coryphe* with 29–33, usually 32 marginal setae (in *M. forceps* 26–30 marginal setae).

Maxilliped 1 (Fig. 4H): Nearly identical; epipodite differs slightly in having usually 6, sometimes 7, marginal and terminal setae.

Maxilliped 3 (Fig. 4J): Similar; variation in epipodite setation ranges from 0–2 lateral, and 2–6 terminal setae in both species, thus both overlap.

Pereiopods (Fig. 5D–F): Chelipeds essentially similar in form, varying in setation (probably not significantly); mean ratio (N = 5 specimens) of movable finger to palm in *M. coryphe* = 1.37; this ratio in *M. forceps* = 1.24; walking legs more or less identical in general appearance; dactyls slightly shorter relative to propodus (0.78 in *M. coryphe,* 0.88 in *M. forceps*) on first walking leg (pereiopod 2); coxal and ischial spines present both species, figured, but inadvertently not discussed in our account of *M. forceps*; coxal spine in *M. coryphe* with 1 seta, in *M. forceps* with 2.

Color: Differs from *M. forceps*. Carapace anteriorly rose-orange, posteriorly transparent, with paired black chromatophores only dorsally; gut black interiorly; chelipeds and all walking legs rose-orange, darker on ischium, merus, carpus, lighter on propodus and dactyl. Abdominal somites 1–2 clear, 3–6 rose-orange; telson overall rose-orange, without individual chromatophore. Peripheral ommatidia of eyes reflect rose-orange, corneas dark. Rostrum, antennule and antennae clear, without chromatophores or diffuse coloration.

Discussion

From the preceding description it is obvious that the zoeal and megalopal stages of *Mithrax coryphe* will be extremely difficult to distinguish from those of its closely related congener, *M. forceps*. Except for minor variation in appendage armature, which may eventually prove to be insignificant, the larval and postlarval stages are nearly identical. The most noticeable difference between the two species is in the coloration of live specimens on the zoeal and megalopal stages, with the two species more easily separated in the megalopal stage. In general, the carapace, telson and walking legs of *M. coryphe* are rose-orange, whereas in *M. forceps* the colors are golden-brown and greenish-gold, respectively, with nearly transparent walking legs. Postlarvae of the two species also differ in positioning and number of chromatophores, with *M. coryphe* having but a single pair dorsally on the carapace (2 pairs in *M. forceps*), no chromatophores on abdominal somites 1 and 2 (a black, and several red chromatophores, respectively, on these somites in *M. forceps*), and none on the mouthparts (several black chromatophores on the mandibles, labrum, and protopodites of maxilliped 3 in *M. forceps*).

In addition to color, *M. coryphe* differs in the megalopal stage from *M. forceps* in size (slightly larger), dorsal tuberculation on the carapace (1 more gastric, 1 less intestinal tubercle), overall carapacial setation (slightly more setose), in the number of antennular aesthetascs (9 instead of 7), and the number of marginal setae on the scaphognathite (29–33, as against 26–30 in *M. forceps*). The higher ratio of the movable finger to the palm length of the chelipeds in *M. coryphe* may prove to be of some value, although too few specimens were available to allow firm conclusions in this respect.

In a previous paper (Wilson *et al.*, 1979) we compared the larval stages of *Mithrax* (*Mithraculus*) *forceps* to the first zoea of *Mithrax* (*Mithrax*) *pleuracanthus*, and to the larval and postlarvae of *M.* (*Mithrax*) *spinosissimus*. We found very little difference between *M. forceps* and *M. pleuracanthus* on the one hand, but considerable differences between *M. forceps* and *M. spinosissimus*, on the other. This demonstrated that characters defining subgenera at the adult level may not be useful at the larval level. Moreover, the very great similarity between *M. coryphe* and *M. forceps* larvae in this study, and thus to *M. pleuracanthus* larvae (at least in the first stage), supports previous observations (e.g. Yang, 1976) that many of the species in the various majid genera in which the larvae are known show a remarkable consistency in larval characters, making them difficult to separate in the plankton. *Mithrax coryphe* thus becomes the second species in the subgenus *Mithraculus* in which the larvae appear similar to at least one species in the subgenus *Mithrax* (i.e. *M. pleuracanthus*), although differing considerably from another (*M. spinosissimus*, Provenzano and Brownell, 1977).

The great similarity exhibited by the larvae of *M. coryphe* and *M. forceps* is carried over into the adult stage to some degree. Adults of both species have oblique branchial sulci on the carapace dorsum, but are distinguished chiefly by the number and armature of the anterolateral lobes (3, bluntly rounded in *M. coryphe*; 4, spine-tipped in *M. forceps*), and whether the cheliped carpus is dorsally nodose (*M. coryphe*) or smooth (*M. forceps*). The gonopods in males of the two species show noticeable differences with that of *M. coryphe* morphologically much simpler (Fig. 6). It would appear that differentiation between the species is first observable at a very early stage, probably the megalopa, based on our studies.

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Smithsonian Institution, Fort Pierce Bureau, Fort Pierce, Florida 33450.